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MEMORANDUM

TO: Patrick Goddard, Director of Facilities, Town of Lexington
Paul B. Ash, Ph.D, Superintendent, Lexington Public Schools

FROM: David L. MacIntosh, Sc.D., Principal Scientist
Matt A. Fragala, M.S., C.I.H., Senior Scientist

DATE: August 29, 2011

RE: Planned Refinement to the Operation and Maintenance Plan, Estabrook Elementary School, Lexington, Massachusetts (EH&E 17892)

This memorandum provides a summary of recent assessments intended to identify opportunities for additional mitigation of polychlorinated biphenyl (PCB) concentrations in indoor air of Estabrook Elementary School (Estabrook), Lexington, Massachusetts.

SUMMARY

Further investigation and analysis of PCB concentrations in indoor air of Estabrook was undertaken during July – August, 2011. The primary conclusions of this work are:

- After having encapsulated the primary sources of PCBs and standardized ventilation in Estabrook, variation in ambient temperature now appears to be an important determinant of PCB concentrations in indoor air of the school, with higher temperature leading to higher concentrations.

- A combination of additional engineering and administrative controls can increase ventilation and mitigate PCB concentrations during periods of elevated temperature.

- School-year average concentrations at Estabrook *going forward* are estimated to range from 115 to 125 nanograms per cubic meter (ng/m^3), approximately 2-fold lower than the health protective target of 230 ng/m^3.

Based on the findings of the additional monitoring and analyses described in this memorandum the Operations and Maintenance (O&M) Plan will be revised to institute the following additional engineering and administrative controls to manage PCB levels at Estabrook during the non-heating season:

- Thermostat set points to minimum position (63 degrees Fahrenheit [°F])
- Continuous operation of unit ventilators in classrooms
- Continuous operation of central exhaust systems
- Open windows and classroom doors during school hours except when not feasible because of precipitation or cool temperatures

In addition, information on ambient temperature during sampling will be used to assist in the interpretation of any future occurrences of indoor air PCB concentrations above the action level established in the O&M Plan.

These refinements to the O&M Plan are consistent with the goal of achieving PCB levels in Estabrook that are as low as reasonably achievable.

DETAILS

Investigation in Follow-up to May and June 2011 Sampling

As described in the Environmental Health & Engineering, Inc. (EH&E) memorandum dated July 5, 2011, air samples collected on May 21 and June 9, 2011, revealed concentrations of PCBs in 4 rooms that exceeded the threshold (173 ng/m^3) for further investigation. Ventilation and ambient temperature were identified as factors that contributed to the indoor air concentrations of PCBs observed on those days. A discussion of the influence of ambient temperature on the indoor air concentrations of PCBs at Estabrook can be found in the next section of this memorandum.

As also described in the July 5, 2011, memorandum, a plan was developed to provide additional ventilation to the school during the non-heating season. The plan called for 1) adjusting the thermostat in each room to its lowest setting, 63 °F; 2) operating unit ventilators 24 hours a day; 3) operating the central exhaust systems 24 hours a day; and 4) opening windows and

classroom doors during occupied hours. According to Estabrook staff, opening windows is common practice during periods of warm weather and classroom doors are generally open throughout the school year.

Air sampling was conducted on July 13 – 14, 2011, to evaluate the effectiveness of additional ventilation during the non-heating season. On July 12, 2011, prior to the sampling, thermostat set points were adjusted to 63 °F and unit ventilators and exhaust systems were put into continuous operation throughout Estabrook. Seven rooms were sampled for PCBs in indoor air between approximately 8:00 a.m. and 2:00 p.m. on July 13 – 14, 2011. In rooms 6, 24, 31B, and the Library, the windows and classroom doors were opened at 6:00 a.m. and closed at 5:00 p.m. on both days of sampling. In rooms 2, 22, and 31A, windows and doors were closed in accordance with all previous indoor air sampling at Estabrook. The air exchange rate in a subset of the rooms (2, 6, 22, 24, 31A, 31B) was measured using a standard tracer gas (sulfur hexafluoride) technique.

PCB levels in rooms with open windows and doors were lower than in the closed rooms in general. Concentrations of PCBs in indoor air of the rooms with open windows ranged from 9 to 263 ng/m^3 with a median of 140 ng/m^3. In comparison, concentrations in rooms with closed windows and doors ranged from 43 to 337 ng/m^3 with a median of 176 ng/m^3 on July 13 – 14, 2011, and from 103 to 386 ng/m^3, median 158 ng/m^3 on May 21 and June 9, 2011. Ambient temperatures during the July 13 – 14, 2011, sampling were 82 and 72 °F, respectively, and comparable to the temperatures during the indoor air sampling conducted in May and June of 71 and 80 °F. Differences in concentrations between rooms with open and closed windows may be explained in part by air exchange rate. Air exchange rates in the rooms with open windows and doors ranged from 5.7 to 10.7 per hour, approximately 2.5 times greater than air exchange rates for the rooms with closed windows and doors. A portion of the greater air exchange achieved with open windows and doors may be the result of air movement within Estabrook rather than infiltration of outdoor air.

Overall, these results indicate that increasing ventilation through a combination of additional engineering and administrative controls provides further mitigation of PCB concentrations in indoor air of the school over and above the controls described in the current O&M Plan for PCBs at Estabrook.

Indoor Air PCB Levels and Temperature

EH&E memorandums and reports distributed from August through November 2010, demonstrated the efficacy of improved ventilation, encapsulation, and physical barriers at reducing and controlling concentrations of PCBs in indoor air of Estabrook. Since completion of the first mini-walls (physical barriers) in November 2010, EH&E has periodically monitored PCB levels in indoor air of the school. This section presents an analysis of PCB concentrations over time, focusing on their relationship with ambient temperature. Implications of the findings for indoor air levels of PCBs in future school years are discussed at the end of this section.

After the mini-wall construction at Estabrook, a total of 90 indoor air samples were collected between November, 2010 and July, 2011. At least one round of samples was obtained in each month except January. Corresponding ambient temperature data was obtained from a weather station located at Hanscom Field approximately 0.4 kilometers west of the school.

The plots in Figure 1 demonstrate a strong relationship between PCB concentrations in indoor air of Estabrook and ambient temperature for the period of November 4, 2010 – July 14, 2011. The exponential relationship between temperature and PCB concentration shown in Figure 1a is consistent with first principles of physical chemistry. As shown in Figure 1b, ambient temperature explains 86% of the variation in indoor PCB concentration.

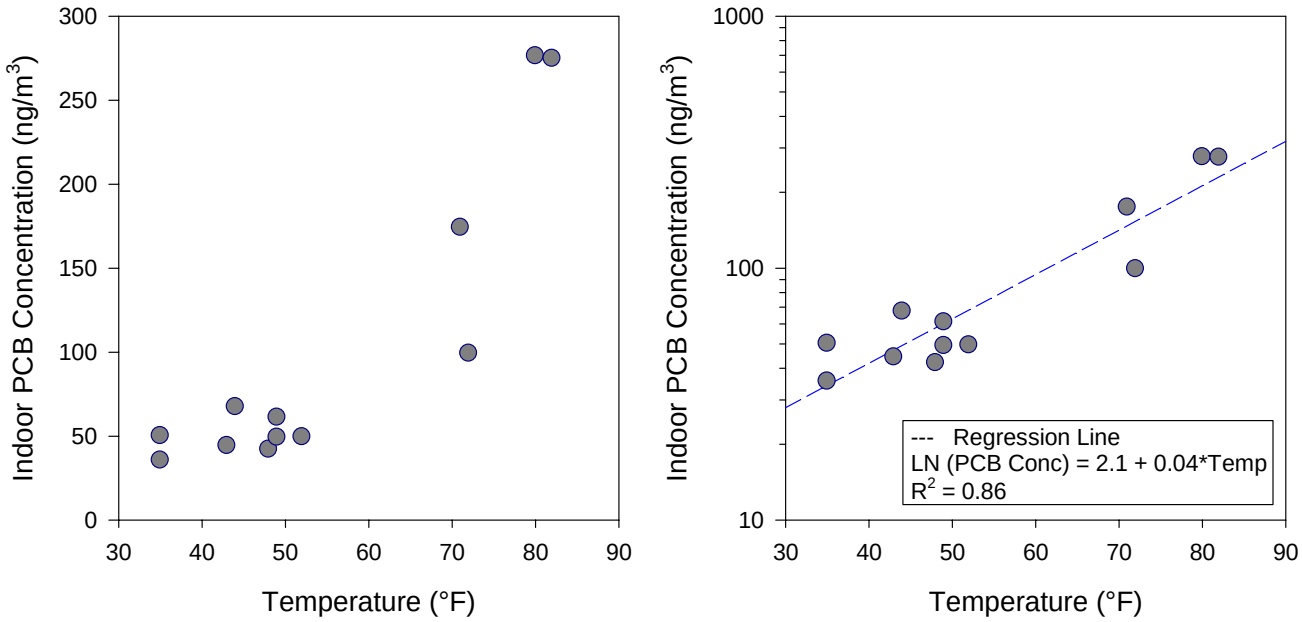

Figure 1a Scatterplot of Indoor PCB Concentration and Temperature
Figure 1b Scatterplot of Log-transformed Indoor PCB Concentration and Temperature

The relationship between average indoor air PCB concentration in the original classrooms of Estabrook and average ambient temperature since November 4, 2010, is shown in Equation 1. A 'rule of thumb' interpretation of the equation is that PCB levels in indoor air increase by approximately 4% for every degree Fahrenheit increase in temperature.

$$PCB\ (ng/m^3) = 2.1 * Temperature\ (°F)^{0.04} \qquad \text{Equation 1}$$

PCB Levels in Indoor Air of Estabrook, 2010 – 2011

The mathematical relationship shown in Equation 1 was used to estimate past daily average indoor air PCB concentrations of classrooms in the original building at Estabrook after mini-walls were constructed. A plot of daily estimated school-wide average PCB concentrations for November 4, 2010, through June 17, 2011, the end of the 2010 – 2011 school year, is shown in Figure 2. The predicted indoor PCB concentration during a typical school period (8 a.m. – 3 p.m.) is shown on the Y-axis. A reference line equivalent to the PCB action level of 173 ng/m^3, is shown as well.

This plot indicates that average concentrations are expected to have been below 173 ng/m^3 on most days over that period with a steady increase to about 200 ng/m^3 throughout the spring. The plot also demonstrates that indoor air PCB levels above the action level should be expected to occur on occasion. Based on the values shown in Figure 2, 25 days between November 4, 2010, and June 17, 2011, are predicted to have been above the threshold for action. This knowledge is important for responding to results of future routine monitoring at Estabrook.

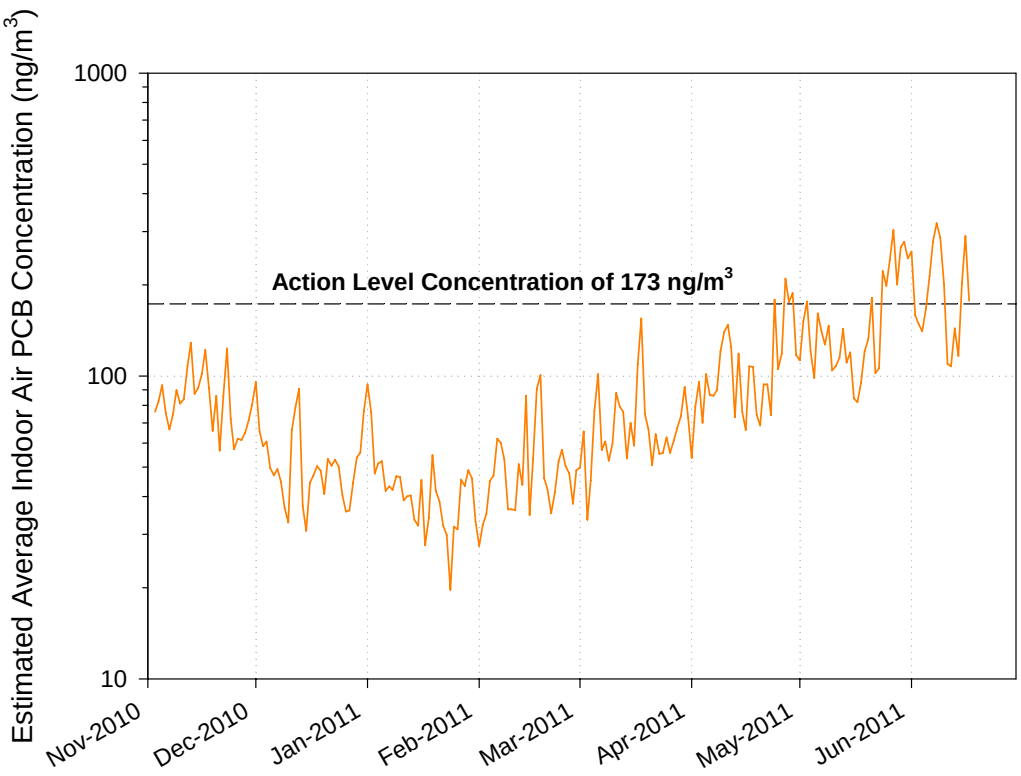

Figure 2 Daily Predicted Indoor PCB Concentration and Outdoor Temperature, November 4, 2010 – June 17, 2011, Estabrook Elementary School, Lexington, Massachusetts

Future PCB Levels in Indoor Air of Estabrook

By applying Equation 1, future school-year average concentrations of PCBs in indoor air were estimated to range from 115 to 125 ng/m^3. The predicted school-year average concentrations are approximately 2-fold lower than the health protective target of 230 ng/m^3 established through the site-specific risk assessment for Estabrook. As in 2010 – 2011, the action level is expected to be triggered in future years also. The school-day average concentration was

predicted to be greater than 173 ng/m^3 on 32 to 38 days per school year. The model also predicts concentrations to be less than 100 ng/m^3 on 66 to 92 days per school year. School year is defined here as August 31 – June 16.

These estimates were obtained by using representative temperature data from Hanscom Field and assuming that the concentration-temperature relationship observed since November 4, 2010, will hold into the near future. Following U.S. Environmental Protection Agency guidance for air modeling, the six most recent years of meteorological records from Hanscom Field were used to represent typical variation in temperature. The high level of precision in the relationship between indoor air PCB levels and ambient temperature shown in Figure 1 indicates that the effectiveness of the mitigation measures taken to date has been constant over time. This observation provides a basis for relying on Equation 1 to characterize likely airborne PCB concentrations in Estabrook into the future.

Refinements to the Operations and Maintenance Plan

Based on the findings of the additional monitoring and analyses described in this memorandum, the O&M Plan will be revised to institute the following additional engineering and administrative controls to manage PCB levels at Estabrook during the non-heating season:

- Thermostat set points to minimum position (63 °F)
- Continuous operation of unit ventilators in classrooms
- Continuous operation of central exhaust systems
- Open windows and classroom doors during school hours except when not feasible because of precipitation or cool temperatures

In addition, information on ambient temperature during sampling will be used to assist in the interpretation of any future occurrences of indoor air PCB concentrations above the action level.

If you have any questions regarding this memorandum, please do not hesitate to contact either of us at 1-800-TALK EHE (1-800-825-5343).